Genetic Events in Rat Populations at Eniwetok Atoll[1]

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ENIWETOK ATOLL in the northern Marshall Islands has resident populations of three rodent species: the roof rat, *Rattus rattus;* the Polynesian rat, *R. exulans;* and the house mouse, *Mus musculus.* This atoll is 388 square miles with a land area of but 2.26 square miles consisting of 40 low coral islands surrounding a central lagoon. The climate is tropical marine. The islands at the present time are an ideal laboratory for the study and manipulation of small, limited populations of species capable of survival there. The islands have been greatly modified by German rule, then Japanese control, by allied invasion during World War II, and, further, by a series of 40 atomic test blasts from 1948 to 1958 carried out by the Atomic Energy Commission. For a diagram of the atoll, and a more complete history, see Jackson (1969).

The work reported here is a follow-up study to work begun 2 years ago (Malecha and Tamarin, 1969). Trapping was conducted at the same three islands—Engebi, Runit, and Parry—in the summer of 1970 as previously reported and the same electrophoretic techniques of blood plasma were used. Rats were trapped for 2 or 3 consecutive nights using Japanese live traps, bled by heart puncture or tail clip, and released on the same or a different island. The trapping areas were identical to, or contiguous with, the 1968 areas.

All three islands contain mono-species populations and all islets are in various early successional stages because of recent man-made decimation and habitation (Jackson et al., 1969). Engebi, with the largest rat population, has had the greatest chance to recover from human activities. Runit was the site of the last atomic tests and has the highest background radiation; and Parry, until recently, had a human population present. Engebi is larger (316 acres) than Runit (75 acres) or Parry (195 acres).

Transferrin Gene Frequencies

Table 1 presents a comparison of gene and genotypes between the 1968 and 1970 samples. Before comparisons between years were examined, differences were looked at between sexes and between the expected genotype arrays on the basis of Hardy-Weinberg equilibrium for the 1970 sample. There were no significant differences. However, there were significant differences between years. Chi-square tests on gene and genotype arrays were significantly different for Runit ($p < 0.001$) and nonsignificant for Engebi. For Parry Islet, the apparent fixation in 1970 of the Tf^C allele is significantly different from the 1968 sample if we assume that Tf^C frequency was not significantly different in the 2 years and that the 1970 sample did not pick up the Tf^B and Tf^D alleles ($p < 0.01$; see Snedecor and Cochran, 1967, table 1.4.1). We may thus conclude that there have been significant genetic changes at Runit and Parry islets. At Runit there was an increase in the Tf^A allele and a decrease in the Tf^B allele. At Parry, a low Tf^B and Tf^D frequency went to fixation of the Tf^C allele.

Little can be said at this time regarding the forces affecting the changes. The genetic history of these islet populations is virtually unknown, and different genetic founders may account for the allele frequency differences initially found between islets. The changes from 1968 to 1970 could have been produced by genetic drift or, alternatively, by selective changes. One way to study possible selective factors is by population manipulation.

Introduction of rats to islets has been tried

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TABLE 1

COMPARISON OF GENOTYPE NUMBER AND GENE FREQUENCY FOR THE FIVE TRANSFERRIN ALLELES ON THREE ISLETS OF ENIWETOK ATOLL BETWEEN 1968 AND 1970

ISLET	YEAR	NUMBER											FREQUENCY				
		T^fAT^fA	T^fAT^fB	T^fAT^fC	T^fBT^fB	T^fBT^fC	T^fCT^fC	T^fCT^fD	T^fCT^fE	T^fET^fE	T^fA	T^fB	T^fC	T^fD	T^fE
Runit	1968	0	0	1	6	13	12	–	–	–	0.016	0.391	0.594	–	–
(Yvonne)	1970	5	4	8	1	1	13	–	–	–	0.344	0.109	0.547	–	–
Engebi	1968	–	–	–	–	–	1	–	2	10		–	0.154	–	0.846
(Janet)	1970	–	–	–	–	–	2	–	11	25		–	0.197	–	0.803
Parry	1968	–	–	–	0	1	15	1	–	–		0.029	0.941	0.029	–
(Elmer)	1970	–	–	–	–	–	28	–	–	–		–	1.000	–	–

before at Eniwetok (Jackson et al., 1969) and at Ponape in the Caroline Islands (Jackson and Strecker, 1962). The Ponape experiment resulted in failure of the populations to survive, presumably due to the small size of the islets. As part of our 1970 fieldwork, introductions of known genotype animals were made to the following islands: Mujinkarikku, 9 males, 6 females; Billee, 9 males, 6 females; Japtan, 10 males, 10 females; and Muti, 9 males, 7 females. It is hoped that follow-up studies in the future will elucidate some of the factors affecting selection, especially since Muti previously only had Polynesian rat populations and thus effects of competition might be seen.

Coat Color

R. rattus exhibits a pelage color polymorphism controlled by two loci (Tomich and Kami, 1966). The standard wild type is an agouti dorsum and white venter. The black form can result from a recessive gene pair at the agouti locus or a dominant gene at another locus, called the black extension series locus. A black color form of *R. rattus* has been found at Eniwetok only on Runit, and, as indicated from limited breeding data (Jackson et al., 1969), appears to be the dominant black form. Jackson et al. (1969) report an increase in the black form from 46 percent in 1965 to 56 percent in 1966 to 77 percent in 1967. In our 1970 data, we found a frequency of 56 percent. This is significantly different from their 1967 sample (chi-square $= 5.246$, $p < 0.025$) and represents a return to the frequency found in 1966. Jackson et al. (1969) attribute the change to genetic drift due to the small population size which was estimated to be about 500 individuals. Tomich (1968), however, found evidence for selection in this system on the island of Hawaii. Although we would initially think that a coat color polymorphism is maintained by visual predation pressure, this has never been demonstrated. Thus, the absence of rodent predators at Eniwetok does not mean that the selection is not acting on the pelage color locus. Part of our colonizing experiment involved color forms and future data here may elucidate the controlling factors.

Reproductive Data

In addition to taking genetic data we numbered, weighed, and sexed all animals captured; we also maintained records of the following reproductive information: males—scrotal or abdominal testes position; females—perforate or nonperforate vaginas; small, medium, or large nipples; and obvious gravidity.

Jackson et al. (1969) found no significant deviation from a 1:1 sex ratio in a sample size of 507 roof rats. We, however, found a significant male excess in a sample of 100 (males = 61%, chi-square = 4.840, $p < 0.05$). The three populations we sampled were statistically homogeneous in respect to sex ratio with Parry having the highest percentage males, 71.4 percent. When the data were broken down into weight groups, the lower weight animals, 1 to 129 grams, had a higher female ratio (41.9 percent males) and the higher weight animals, 130 to 199 grams, had a male excess (76.8 percent males). This distribution is highly significant (chi-square = 12.530, $p < 0.005$) and disagrees with the data of Jackson et al. (1969) who found no difference by weight class. The higher male excess, especially in higher weight animals, may be due to a lack of sex-specific mortality factors, inasmuch as there is normally a higher secondary sex ratio (Jackson, 1962) and males grow faster. These two factors without sex-specific mortality would produce an overall male excess especially at higher body weights.

Our data on reproduction are in general agreement with Jackson et al. (1969). The majority of animals were reproductively mature adults (scrotal males or perforate females). Five of 33 females and one of 61 males were immature. Only one female was found to be pregnant (on Engebi) and only 9.1 percent of the perforate females were lactating. These data are not inconsistent with high density populations going out of breeding; however, these populations have only been studied during the summers and a year-long study would be most valuable.

SUMMARY

We found statistically significant changes in gene frequency at the transferrin locus at Runit and Parry islets and coat color at Runit from 1968 to 1970 at Eniwetok Atoll. Limited data on reproduction were gathered and sex ratios were consistent with a lack of sex-specific mortality factors. Introduction experiments were begun with the hope of casting light on the genetic changes found; they should be potentially useful also for study competition and population dynamics.

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